5. FLYOVER NOISE LEVELS OF DC-8-55 AIRPLANES WITH ACOUSTICALLY TREATED NACELLES

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SUMMARY

Flyover-noise tests were conducted with a DC-8-55 test airplane equipped first with existing and then with treated nacelles. Tests were conducted in February and March 1969 in the vicinity of Fresno Air Terminal, Fresno, California. Effective perceived-noise levels were derived from 1/3-octave-band sound-pressure levels measured at several stations under the landing and take-off flight paths. Effective perceived-noise levels, with units of effective perceived-noise decibels (EPNdB), were used to evaluate the acoustical effectiveness of the treated nacelles as installed on short-duct DC-8-55 airplanes powered by four JT3D-3B engines.

Reductions in effective perceived-noise level were achieved at locations under both the landing-approach and the initial-climb take-off flight paths. Under a 3^{o} landing-approach flight path at a distance of 1 nautical mile from threshold, an airplane with treated nacelles and the maximum landing gross weight of 240 000 pounds would produce 10.5 EPNdB lower noise levels than an airplane with existing nacelles.

At a point beneath the initial-climb path and 3.5 nautical miles from brake release with the airplane climbing at 10 knots above the FAA take-off safety speed and maintaining rated take-off thrust, the treated nacelles on an airplane with the maximum 325 000-pound take-off gross weight would reduce the effective perceived-noise level by 3.5 EPNdB. Airplanes with lighter take-off weights would achieve less noise reduction. Along a line 1500 feet to the side of the take-off flight path, the treated nacelles would reduce the maximum effective perceived-noise level of the 325 000-pound airplane, at rated take-off thrust, by approximately 3 EPNdB.

By using a reduced-thrust initial-climb procedure in which rated take-off thrust is decreased at 1500 feet before the 3.5-nautical-mile point to the thrust required to maintain a 6-percent climb gradient, the treated nacelles on an airplane weighing 325 000 pounds at take-off would reduce the effective perceived-noise level by 5.5 EPNdB at the 3.5-nautical-mile point. Airplanes dispatched at lighter weights for flights with shorter ranges would achieve larger noise reductions over the 3.5-nautical-mile point than the airplane with the 325 000-pound take-off weight.

Estimates of flyover noise levels made on the basis of sound-pressure levels measured around an engine test stand were compared with measurements obtained during the flyover-noise tests. Reasonably good agreement was found for the treated nacelles in terms of the magnitude and the spectrum of the 1/3-octave-band sound-pressure levels at the instant of maximum perceived-noise level. Good agreement was also obtained between the measured and the predicted variation with time of perceived-noise level during a flyover.

INTRODUCTION

The October 1968 conference on progress in noise-alleviation research described the results of the McDonnell Douglas ground static tests that led to the choice of the treated nacelle selected for flight testing (ref. 1). Since the October 1968 conference, four sets of treated nacelles have been fabricated and flight tested on a DC-8-55 airplane – as reported by Robert E. Pendley in paper no. 3. Flight tests were conducted with the test airplane equipped first with existing and then with treated nacelles. The airplane was powered by four Pratt & Whitney Aircraft JT3D-3B turbofan engines. The flight-test program determined changes in engine and airplane performance and changes in flyover noise levels.

The present paper describes the flyover-noise tests that were conducted and discusses the results that were obtained. Evaluations of the effects of the treated nacelles on flyover noise levels are presented in terms of effective perceived-noise level (EPNL) in units of effective perceived-noise decibels (EPNdB). A comparison is also given between measured and estimated perceived-noise levels (PNL) and between measured and estimated 1/3-octave-band sound-pressure levels (SPL). The values of SPL are in decibels referenced to a pressure of 0.0002 dyne per square centimeter.

SYMBOLS AND ABBREVIATIONS

EPNL effective perceived-noise level, effective perceived-noise decibels (EPNdB)

ΔEPNL difference between values of EPNL obtained with an airplane equipped with existing nacelles and those obtained with an airplane equipped with acoustically treated nacelles, EPNdB

F_n installed net thrust, lb

F_n/δ_{am} referred installed net thrust, lb

N_1	low-pressure rotor speed, rpm
$N_1/\sqrt{\theta_{t_2}}$	referred low-pressure rotor speed, rpm
p_{am}	ambient pressure, lb/ft^2
$p_{am,sl}$	ambient pressure at sea level, 2116 lb/ft^2
PNL	instantaneous perceived-noise level, perceived-noise decibels (PNdB)
PNLM	maximum value of instantaneous perceived-noise level, PNdB
PNLT	tone-corrected instantaneous perceived-noise level, PNdB
PNLTM	maximum value of tone-corrected instantaneous perceived-noise level, PNdB
SPL	sound-pressure level (ref. 0.0002 $dyne/cm^2$), decibels (dB)
$T_{am,std}$	standard-day ambient temperature, 518.7° Rankine
T_{t_2}	total air temperature at inlet-guide-vane station, degrees Rankine
V_2	FAA take-off safety speed, knots (kn)
VHF	very high frequency
δ_{am}	ratio of p_{am} to $p_{am,sl}$
θ_{t_2}	ratio of T_{t_2} to $T_{am,std}$

FLYOVER-NOISE TESTS

All flyover-noise testing was accomplished in February and March 1969 in the vicinity of Fresno Air Terminal, Fresno, California. The airport had a 9200-foot-long main runway and a 2.5° Instrument Landing System. The ground beneath the flight paths was relatively flat with an elevation of 335 ± 15 feet. There were no large obstacles near any sound-recording stations. This section describes some of the general features of the test procedures and the acoustical data reduction.

Test Program

The flyover-noise test program consisted of a series of tests at 12 conditions that were repeated on three different test days for the existing as well as the treated airplane. Table I lists the 12 test conditions and the nominal airplane gross weights that were included in the flyover-noise tests. All airplane weights stated in this paper are gross weights. Figure 1 shows the test airplane with the existing nacelles.

Test Procedures

Figure 2 shows typical locations for the mobile sound-recording stations used for the flyover-noise measurements. All tests were conducted under low-wind conditions permitting downwind take-offs. Most of the recordings were made with the airplane flying over microphones located along the extended center line of the runway. Four microphones were located along a line 1500 feet to the side of the runway to obtain measurements of sideline noise during take-off at the heaviest take-off weight.

For the full-power take-offs (items 1, 5, and 9 of table I), rated take-off engine-pressure ratio was maintained to an altitude of 5000 feet or for 5 minutes, whichever occurred first. The reduced-thrust simulated take-offs (items 2, 3, 6, 7, 10, and 11 of table I) were started from level flight along the center line of the runway at a height of about 300 feet. On arriving at a selected point over the runway, the power levers were adjusted to provide a specified rotor speed and the airplane climbed out at a prescribed airspeed. For the landing approaches (items 4, 8, and 12 of table I), the rotor speed was maintained at selected values throughout the approach to minimize fan-noise variations and to obtain comparable noise recordings of airplanes with the existing and treated nacelles on each test day. The average measured values of airspeed and low-pressure rotor speed are given in table II.

Flyover-noise measurements were made at 10 mobile recording stations that were moved about as required. Figure 3 shows a typical noise-recording station with its portable battery-powered equipment. The microphone and sound-level meter were mounted on a tripod with the microphone 5 feet above the ground and oriented for grazing incidence. Photographs were taken when the airplane was over or opposite a station to supplement the time-correlated onboard space-positioning system. The space-positioning system was used to determine the location of the airplane in space relative to the sound being recorded. A portable VHF transceiver was used to transmit a synchronizing signal to the airplane when it passed over the station. The area where most of the recordings were made was used principally for agriculture, as indicated by the grapevines in the background. At each station, the microphones were located so as to avoid any interference or unusual absorption from adjacent vegetation.

Ambient noise levels at the test sites due to ground-vehicle traffic, farming equipment, and wind were acceptably low except in the 1/3-octave bands at and above 5000 Hz. The ambient levels in these high-frequency bands introduced some data-reduction problems for recordings of the noise propagated through long distances. Figure 4 shows the range of ambient sound-pressure levels that were measured. The value of PNL corresponding to the maximum ambient sound-pressure levels was 73 PNdB; the average ambient PNL was approximately 55 PNdB.

Both surface and low-altitude weather conditions were measured. All surface weather measurements at the test sites were made at approximately the 5-foot microphone height. The measurements consisted of wind speed, wind direction, and wet- and dry-bulb air temperatures. For the tests with the existing nacelles (conducted in February 1969), the ambient air temperatures ranged from 48° to 65° F with corresponding relative humidities of 84 to 40 percent. For the tests with the treated nacelles (conducted in March 1969), the corresponding temperature and relative-humidity values were 43° to 57° F and 81 to 53 percent, respectively. The surface absolute humidity ranged from 5.8 to 7.5 grams per cubic meter. Vertical weather soundings were obtained by an instrumented lightweight airplane. The general results of the vertical soundings are presented in figures 5 and 6. The weather conditions were comparable for the tests of the existing nacelles and the treated nacelles on the DC-8-55 airplane.

Data Reduction

The flyover-noise recordings obtained were reduced into 1/3-octave-band sound-pressure levels by using an analog-to-digital data-reduction system. The 1/3-octave-band SPL data consisted of the spectral and temporal variations of the SPL during each flyover-noise recording. The values of SPL provided the fundamental information needed to evaluate the noise-suppression system and also were used to derive instantaneous perceived-noise levels (PNL), tone-corrected instantaneous perceived-noise levels (PNLT), and effective perceived-noise levels (EPNL). Calculation of these psychoacoustic measures for estimating human annoyance was based on the procedures of reference 2. The PNL calculations used the mathematical formulations of the noy tables given in reference 3.

For each flyover-noise recording, the data-reduction procedure yielded the time variation of the SPL in each of the twenty-four 1/3-octave bands with center frequencies between 50 and 10 000 Hz. The indicated SPL data, system-frequency-response correction factors, and microphone-pressure-response correction factors for each flyover-noise recording for the airplanes with existing and treated nacelles were processed by a digital computer to determine PNL, PNLT, and duration correction factors.

In programing the digital computer to carry out the calculations required for an evaluation in terms of EPNL, the following details were specified for determining duration correction factors:

- Duration correction factors were computed by the integration method.
- The constants in the integration method were adjusted to account for the 0.25-second interval used in sampling the flyover-noise recordings.
- The duration time was determined from the calculated values of PNLT as a function of time during a flyover. The duration time was defined by the points that were 10 PNdB less than the maximum value of PNLT. If a 10-PNdB-down point did not coincide with a calculated value, then the duration time was taken as the difference between the initial and final times for which PNLT was nearest to the value of PNLTM minus 10 PNdB. For those cases with more than one PNLT peak, the applicable limits for the duration time were chosen so as to yield the largest possible duration time.

A sample of the EPNL test results for landing-approach power settings is presented in figure 7 as a function of height above the microphones. The treated nacelles produced substantial noise reductions over the range of heights. The variation of the individual EPNL values from a mean line drawn through the data points was ±1 to ±1.5 EPNdB. From an analysis of the results at other engine power settings, it was found that the variation at the take-off thrust setting was similar to that observed at the landing thrust setting. For the simulated take-offs with reduced thrust, the scatter was larger and on the order of ±2 to ±3 EPNdB.

The flyover-noise measurements were analyzed to yield generalized results of PNLM and EPNL as a function of distance and thrust. With these generalized results, it was possible to account for the effects of the treated nacelles on the noise levels as well as on the airplane performance. Furthermore, the specific test results might be related in this way to operational conditions of wide interest. Appropriate values of installed net thrust for the test results were determined from the thrust—rotor-speed relationship given in figure 8 for Mach numbers ranging from 0 to 0.4.

All the estimates of airport-community noise levels presented in this paper were based on sound-pressure levels corresponding to the test-day atmospheric conditions. Because the weather conditions were comparable for the tests on the existing and the treated nacelles, the noise reductions determined for comparable airplane weights and engine power settings should be correct under the test-day atmospheric conditions.

COMMUNITY NOISE LEVELS

In this paper, noise levels in communities in the vicinity of airports are presented principally for the maximum landing gross weight and the maximum take-off gross weight; for the DC-8-55 airplane, these weights are 240 000 and 325 000 pounds, respectively. These weights and the three-point noise-measuring system (landing, take-off, and sideline noise) were selected because they were proposed in reference 4 for use in certifying the flyover noise levels of jet transports.

Landing-Approach Noise

Figure 9 shows EPNL under a 3° landing-approach flight path for the 240 000-pound landing weight. The required thrust level was 5500 pounds per engine. Directly below the flight path at 1 nautical mile from threshold, the treated airplane reduced the EPNL by 10.5 EPNdB (from 117.5 to 107 EPNdB). The noise reduction below the flight path was approximately constant to nearly 5 nautical miles from threshold, and then it slowly decreased.

The substantial noise reduction achieved by the nacelle treatment was caused by the significant change in the spectral content of the sounds of the two airplanes, as shown in figure 10. The two spectra show the sound-pressure levels occurring at the instant of the maximum value of the PNL (that is, at PNLM) at a location 1 nautical mile from threshold where the airplane is at a height of 370 feet. In the frequency region above 1000 Hz, which contains the combination tones and the fan-blade-passage frequencies, the treated nacelles substantially reduced the values of SPL. Essentially no change occurred to the portion of the spectrum below 800 Hz, which is controlled by jet-exhaust noise.

Additional information on landing-noise levels at a location 1 nautical mile from threshold is presented in figure 11 for an operational range of landing weights from 180 000 to 240 000 pounds. The noise reductions were greater for the lighter weights because of the smaller contribution of jet-exhaust noise. For example, for airplanes with a 180 000-pound landing weight, the noise reduction was approximately 12 EPNdB.

Take-Off Noise

The values of EPNL at locations under the take-off flight path are shown in figure 12 for airplanes with 325 000-pound take-off weights and climbing with a speed of $V_2 + 10$ knots. The speed of $V_2 + 10$ knots is equivalent to a speed of 174 knots at this weight for an air temperature of 59° F and a take-off flap setting of 25°. At 3.5 nautical miles from brake release, the treated nacelles reduced the EPNL of the airplanes by

3.5 EPNdB (from 115 to 111.5 EPNdB). Airplanes with lower take-off weights would achieve less noise reduction at rated take-off power settings. For example, at a take-off weight of 240 000 pounds, representative of a transcontinental range of 2500 nautical miles, the noise reduction would be 2 EPNdB (from 105.5 to 103.5 EPNdB). The values of EPNL are considerably lower at this weight because of the better climb capability of the 240 000-pound airplane compared with that of the 325 000-pound airplane.

The noise reductions achieved at the take-off power setting are smaller than those at the landing power setting because of the increased intensity of the low-frequency jet-exhaust noise. Figure 13 shows the SPL spectra at the time of PNLM at a location 3.5 nautical miles from brake release. The approximate heights of the airplanes were 975 feet for the airplane with the existing nacelles and 930 feet for the airplane with the treated nacelles. This difference in heights reflects the loss in rated take-off thrust due to the treatment. Although the blade-passage tones were significantly reduced at this rated take-off thrust setting, the relatively more intense jet-exhaust noise determines the PNL of the treated nacelles.

If the thrust can be reduced during the initial climb after lift-off, then lower values of EPNL and larger noise reductions can be achieved at the 3.5-nautical-mile point. For comparison purposes, it was assumed that the thrust could be reduced to that required to maintain a 6-percent climb gradient with a rate of climb of approximately 1000 feet per minute and an airspeed of $V_2 + 10$ knots. The climb procedure assumed a thrust reduction from rated take-off power at a point 1500 feet before the 3.5-nautical-mile point. Figure 14 shows the resultant noise levels. With the 325 000-pound take-off weight, use of this thrust-reduction procedure yielded a noise reduction of approximately 5.5 EPNdB. With a take-off weight of 240 000 pounds, the corresponding noise reduction was approximately 8 EPNdB. Larger noise reductions were achieved with the lighter take-off weights because of the lower thrusts required to maintain the 6-percent climb gradient at these weights. At the distances considered, the contribution of jet-exhaust noise to the PNL decreases as the thrust is reduced on the JT3D-3B engine.

Sideline Noise

The noise levels along the 1500-foot sideline are shown in figure 15 as a function of distance from brake release for airplanes with a 325 000-pound take-off weight and climbing with rated take-off thrust. The difference between the maximum value of EPNL for the existing nacelle and that for the treated nacelle was approximately 3 EPNdB and occurred at 3.5 to 4 nautical miles from brake release. The maximum values of 109 and 106 EPNdB occurred when the airplanes with the existing and treated nacelles were at heights of approximately 900 feet and 1100 feet, respectively. Airplanes with lighter take-off weights (for example, 240 000 pounds) would achieve the same amount of noise reduction.

Estimated EPNL Contours

The approximate extent of the changes in the noise-exposed areas around an airport are indicated in figures 16 and 17. The estimated contours of equal EPNL are drawn at a representative 100-EPNdB level for the existing and the treated airplanes. The scale of the contours is in nautical miles and is the same in both directions. For the landing-noise contours in figure 16, the scale is relative to the threshold end of the runway. For the take-off-noise contours in figure 17, the scale is relative to the brake release point.

During the landing approach (fig. 16), the estimated contour lines indicated that the treated nacelles would produce a substantial reduction in the area exposed to levels of 100 EPNdB or higher. The change in the area exposed to noise levels of 100 EPNdB or higher was much less for take-off (fig. 17) than for landing (fig. 16).

ESTIMATED AND MEASURED NOISE LEVELS

The flyover-noise data obtained in this program afforded an opportunity to validate the flyover-noise estimation method that was described in reference 1. Figure 18 shows comparisons of measured and estimated values of PNL. A comparison of the estimated and measured SPL at the time of PNLM is shown in figure 19 for the airplane equipped with treated nacelles. The comparisons in both figures are shown for a selected landing power setting and for a height overhead of approximately 400 feet.

The predictions were based on SPL measurements at a distance of 150 feet around an engine test stand. The estimated values (dashed lines) were adjusted to the engine conditions of the measurements. The measured data in figure 18 (solid lines) are not representative of the average difference between the noise level of airplanes with the existing and the treated nacelles.

The agreement between the measured and estimated values of PNL and SPL is encouraging, especially because of the considerable difference between the SPL spectra of the existing and treated nacelles. The differences between the measured and estimated values of PNL in figure 18 at times away from the peak values would result in a negligible difference in the integrated duration correction factor in EPNL calculations. It is anticipated that these encouraging results will stimulate further efforts to develop a general prediction technique applicable to engines other than the JT3D-3B and to nacelle treatments other than that used in this program.

CONCLUDING REMARKS

Evaluation of the flyover-noise test results has shown that installation of acoustically treated nacelles on a DC-8-55 airplane achieved noise reductions under both the

landing-approach and the take-off flight paths. Estimates of the flyover noise levels at locations under the landing-approach flight path were made based on sound-pressure-level measurements around an engine test stand. Comparison with flyover-noise measurements indicated reasonably good agreement for both perceived-noise levels and 1/3-octave-band sound-pressure levels. Tables III and IV summarize the principal results, which are as follows:

- Under the landing-approach path, at 1 nautical mile from threshold, the treated nacelles reduced the EPNL by 10.5 EPNdB for an airplane with a 240 000-pound landing weight and by 12 EPNdB for an airplane with a 180 000-pound landing weight.
- Under the initial-climb flight path, at a point 3.5 nautical miles from brake release, a 325 000-pound airplane with treated nacelles achieved a 3.5-EPNdB noise reduction and a 240 000-pound airplane with treated nacelles achieved a 2-EPNdB reduction when climbing with rated take-off thrust. With the thrust reduced to that required to maintain a 6-percent climb gradient, the noise reductions achieved were 5.5 EPNdB for an airplane with a 325 000-pound take-off weight and 8 EPNdB for an airplane with a 240 000-pound take-off weight.
- Along a line 1500 feet to the side of the take-off flight path, the treated nacelles reduced the maximum EPNL by approximately 3 EPNdB for airplanes with take-off weights of 325 000 and 240 000 pounds and climbing at rated take-off thrust.

REFERENCES

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2. Sperry, William C.: Aircraft Noise Evaluation. Rep. No. FAA-NO-68-34, FAA, Sept. 1968.
3. Anon.: Definitions and Procedures for Computing the Perceived Noise Level of Aircraft Noise. ARP 865, Soc. Automot. Eng., Nov. 15, 1964.
4. Anon.: Noise Standards: Aircraft Type Certification. Notice of Proposed Rule Making. Department of Transportation, Federal Aviation Administration, [14 CFR Parts 21 and 36] [Docket No. 9337; Notice No. 69-1]. (As published in the Federal Register [34 F.R. 453], Jan. 11, 1969.)

TABLE I.- FLIGHT CONDITIONS FOR FLYOVER-NOISE TESTS

Test item	Flight operation	Nominal gross weight, lb
1	Take-off	300 000
2	Simulated take-off	295 000
3	Simulated take-off	245 000
4	Landing	240 000
5	Take-off	235 000
6	Simulated take-off	230 000
7	Simulated take-off	225 000
8	Landing	205 000
9	Take-off	200 000
10	Simulated take-off	195 000
11	Simulated take-off	190 000
12	Landing	185 000

TABLE II.- AVERAGE AIRSPEEDS AND ROTOR SPEEDS DURING FLYOVER-NOISE TESTS

Test item	True airspeed, kn		Referred low-pressure rotor speed, rpm	
	Existing-nacelle tests	Treated-nacelle tests	Existing-nacelle tests	Treated-nacelle tests
1	Static to 220	Static to 220	6540	6420
5	Static to 200	Static to 200	6570	6440
9	Static to 195	Static to 195	6590	6460
2	245	245	5900	5890
6	215	210	5860	5930
10	190	190	5880	5930
3	225	225	5520	5540
7	205	205	5500	5550
11	185	185	5510	5570
4	155	160	4705	4730
8	140	150	4500	4400
12	131	135	4290	4150

TABLE III.- LANDING NOISE REDUCTIONS AT 1 NAUTICAL MILE FROM THRESHOLD

Landing weight, lb	ΔEPNL, EPNdB
240 000	10.5
180 000	12

TABLE IV.- TAKE-OFF NOISE REDUCTIONS

Take-off weight, lb	Noise reduction under flight path at 3.5 n. mi. from brake release, ΔEPNL, EPNdB		Reduction in maximum EPNL along 1500-ft sideline, EPNdB
	Rated take-off thrust	Thrust for 6-percent climb gradient	
325 000	3.5	5.5	3
240 000	2	8	3

FLIGHT-TEST AIRPLANE

Figure 1

FLYOVER-NOISE STATIONS

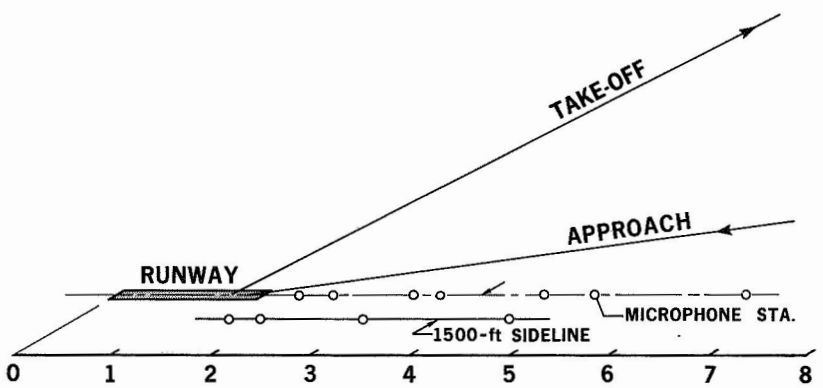

Figure 2

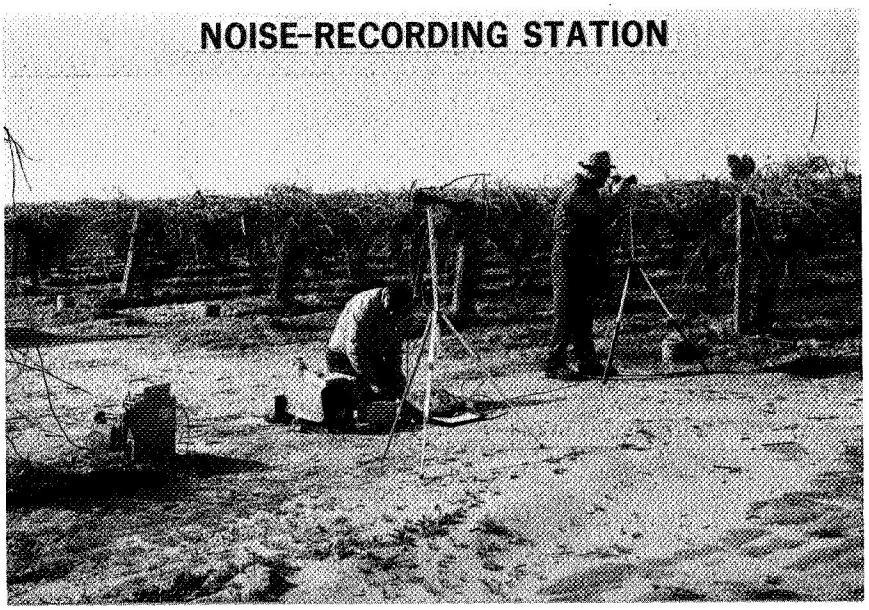

Figure 3

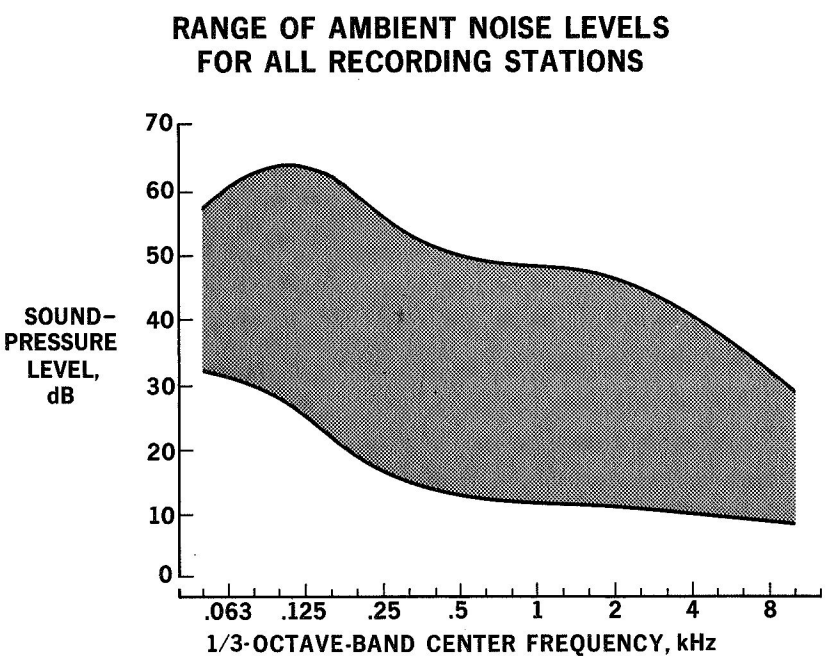

Figure 4

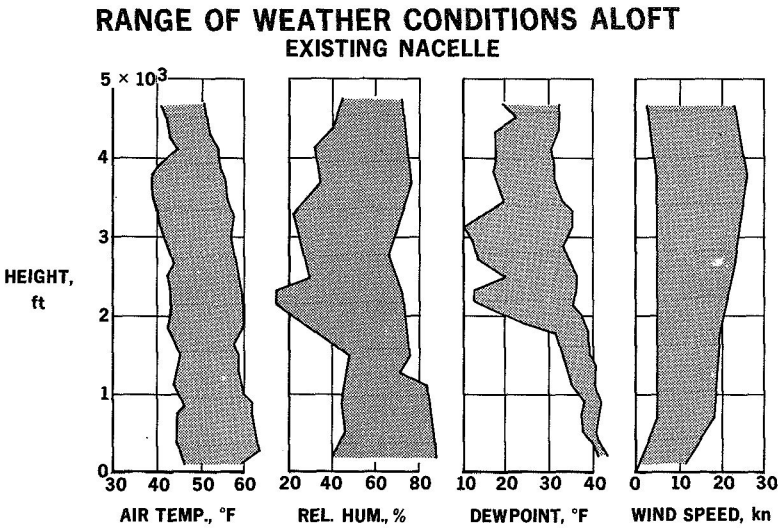

Figure 5

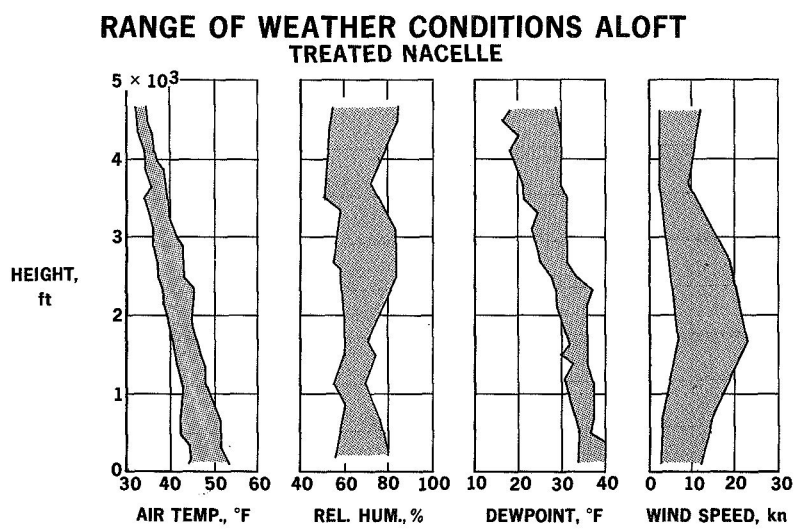

Figure 6

SAMPLE TEST RESULTS
DC-8-55; APPROACH THRUST

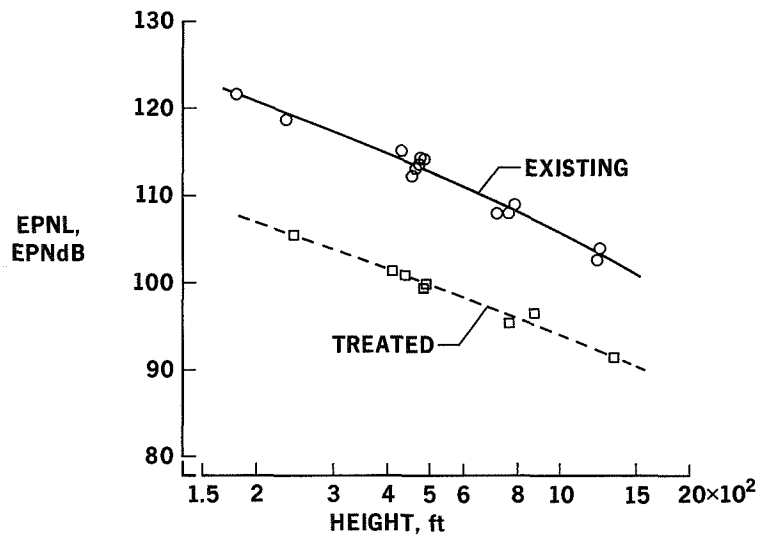

Figure 7

INSTALLED THRUST vs ROTOR SPEED FOR JT3D ENGINES
EXISTING OR TREATED NACELLES

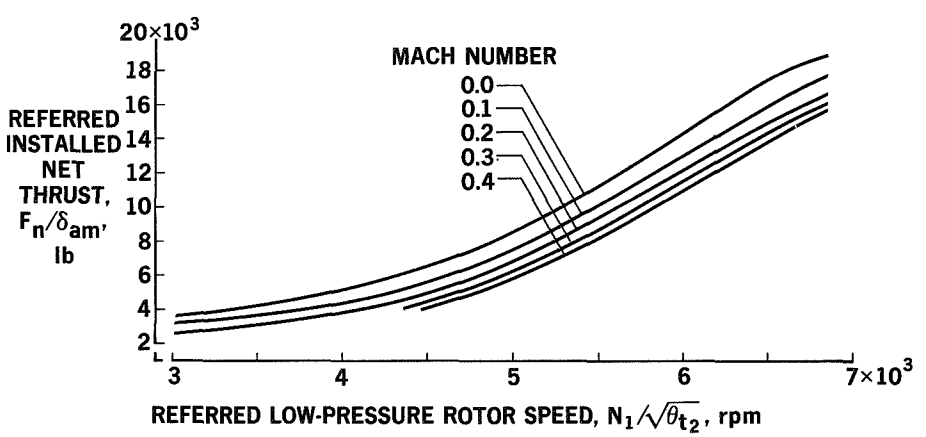

Figure 8

LANDING-APPROACH NOISE LEVELS
240 000-lb LANDING WEIGHT

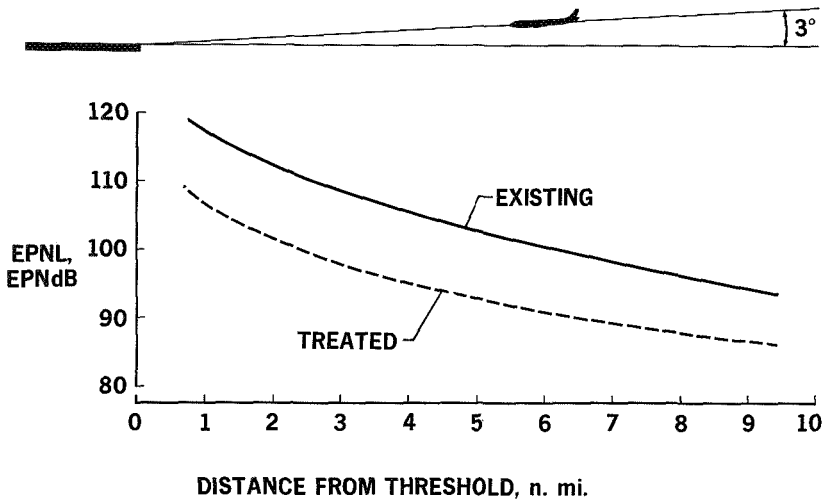

Figure 9

SPL SPECTRA AT TIME OF MAXIMUM PNL
1 n. mi. FROM THRESHOLD; 240 000-lb LANDING WEIGHT

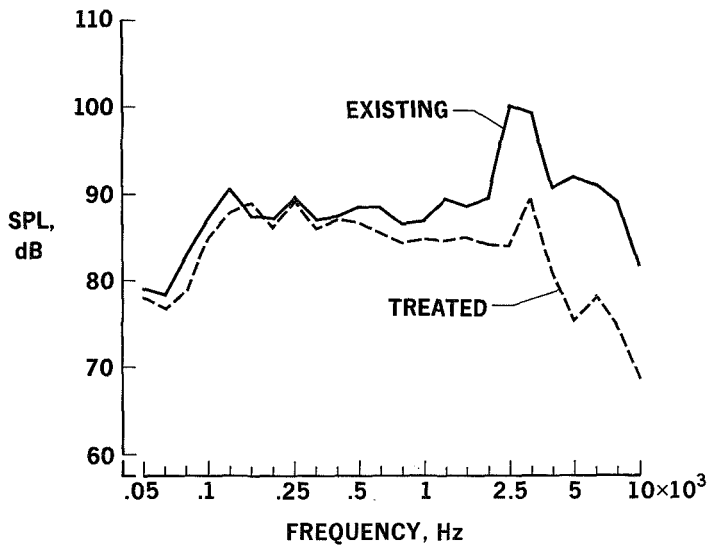

Figure 10

EPNL AT 1 N.MI. FROM THRESHOLD
3° APPROACH FLIGHT PATH

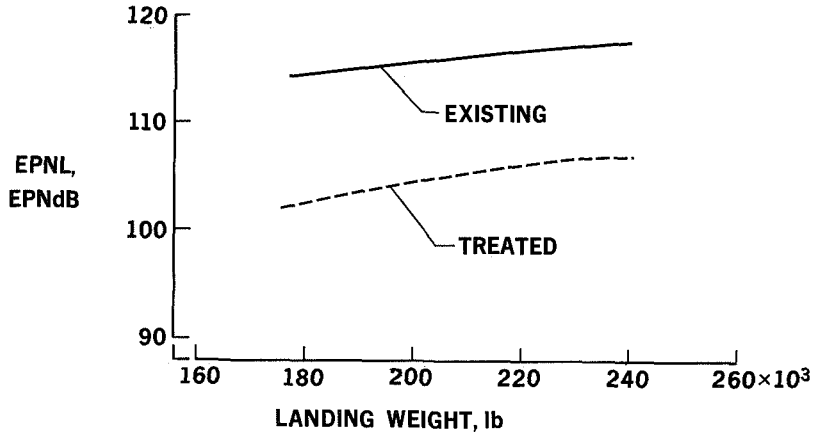

Figure 11

TAKE-OFF NOISE LEVELS
325 000-lb TAKE-OFF WEIGHT; V_2 + 10 knot CLIMB SPEED

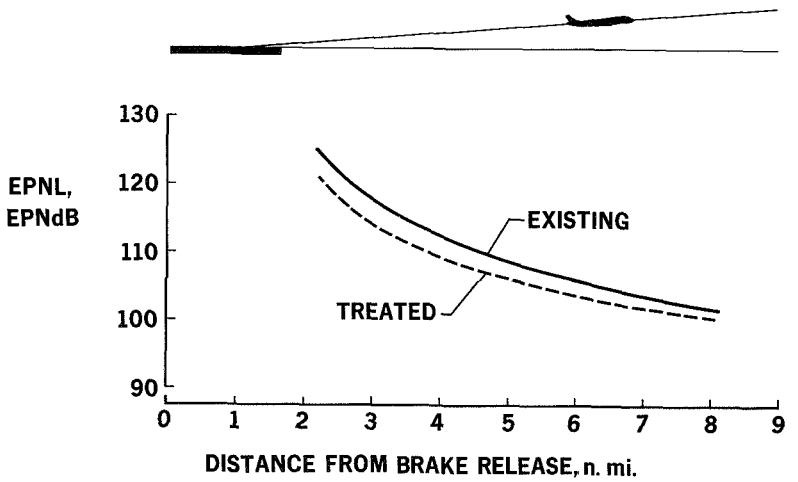

Figure 12

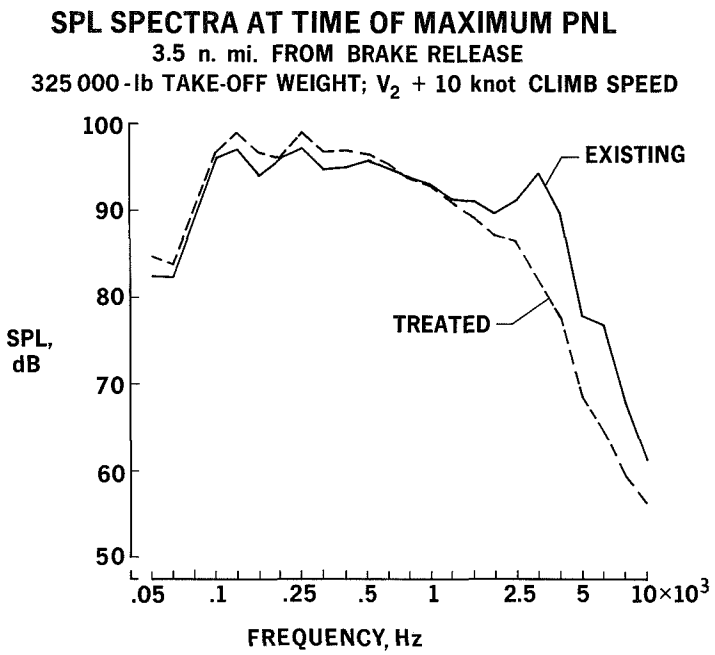

Figure 13

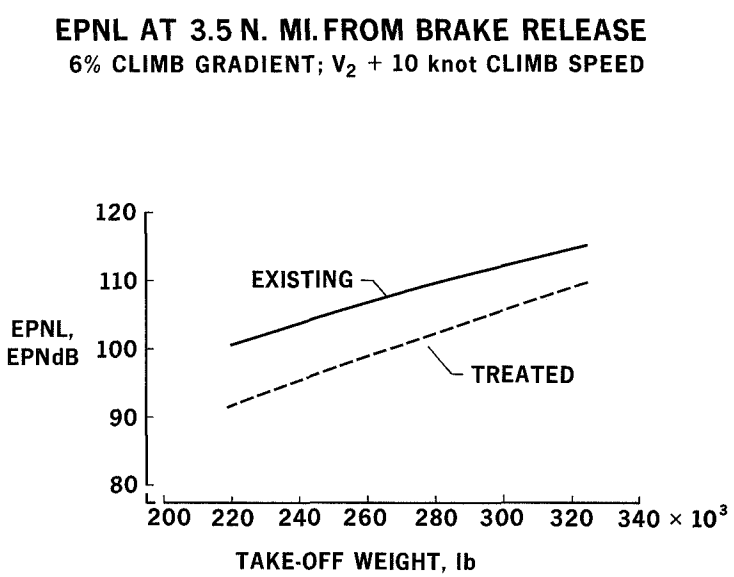

Figure 14

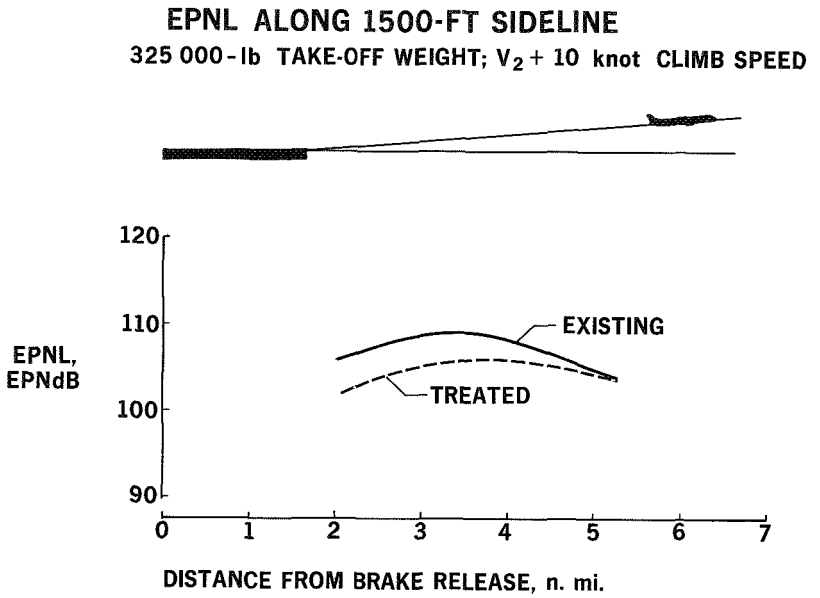
EPNL ALONG 1500-FT SIDELINE
325 000-lb TAKE-OFF WEIGHT; V_2 + 10 knot CLIMB SPEED
EPNL, EPNdB
120
110
100
90
EXISTING
TREATED
0
1
2
3
4
5
6
7
DISTANCE FROM BRAKE RELEASE, n. mi.

Figure 15

ESTIMATED 100-EPNdB CONTOURS

240 000-lb LANDING WEIGHT; 3° APPROACH PATH

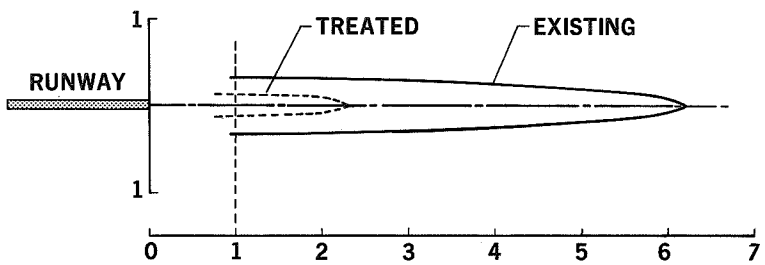

Figure 16

ESTIMATED 100-EPNdB CONTOURS

325 000-lb TAKE-OFF WEIGHT; V_2 + 10 knot CLIMB SPEED

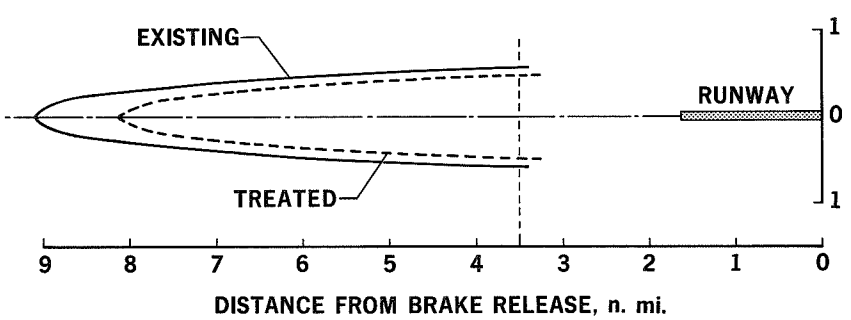

Figure 17

MEASURED AND ESTIMATED PNL

HEIGHT ≈ 400 ft; APPROACH THRUST ≈ 4200 lb/eng

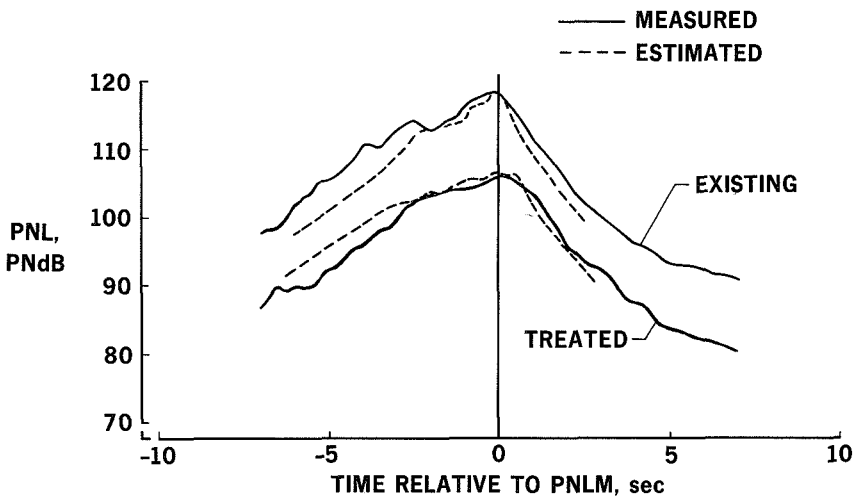

Figure 18

SPL SPECTRA AT TIME OF PNLM FOR TREATED NACELLES

HEIGHT ≈ 400 ft; THRUST ≈ 4200 lb/eng

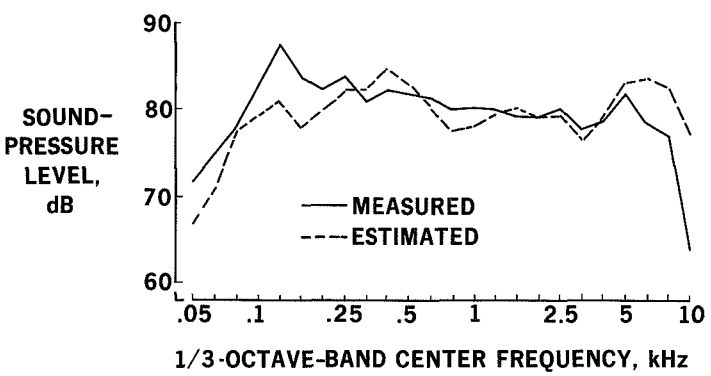

Figure 19